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METHODS OF TESTING THE BURNING QUALITY OF CIGAR TOBACCO.

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METHODS OF TESTING THE BURNING QUALITY OF CIGAR TOBACCO.[a]

INTRODUCTION.

As has been pointed out in previous publications of the Bureau of Plant Industry, a systematic effort is being made to improve the quality and yield of the tobacco crop by employing the latest and most approved methods of selection in the old varieties and by creating and establishing new strains possessing to a marked degree those characteristics most to be desired in the various classes of tobacco which the market demands. This work necessitates the careful testing of a large number of types, as well as many individual selections from each of these types, and for this reason it is very desirable to have at our command methods capable of showing with certainty even slight differences in the essential qualities of the various samples to be examined. It is our purpose to make a careful study of the subject of testing tobacco from a practical standpoint, as well as the relation of the chemical composition of the leaf to its good and bad qualities.

In judging the merits of a cigar tobacco, due regard must be had for the particular use for which it is intended, since the finished cigar consists of three distinct components—the filler, the binder, and the wrapper—each of which must possess certain characteristics. The

[a] In the tobacco breeding experiments conducted by the Plant Breeding Investigations of the Bureau of Plant Industry, particular attention is being given to the improvement of cigar tobaccos, including specially high-grade wrapper and filler types. In connection with these experiments, which are being conducted by Messrs. A. D. Shamel and W. W. Cobey of this Office, it has been found necessary to compare the characters of a large number of selected individual plants to determine which ones are superior in their important characters. The means and methods heretofore used in making such comparative tests were very imperfect, and one important preliminary part of the work is to devise special pieces of apparatus which will enable accurate tests to be made. The devices described by Dr. Garner in the present paper it is believed will greatly facilitate such testing and add to the accuracy of the results. The preliminary notes given by Dr. Garner on the influence of wrapper, binder, and filler on the "burn" of cigars open up an important field of investigation in connection with the testing and breeding of different types of tobacco.—Herbert J. Webber, *Physiologist in Charge of Plant Breeding Investigations.*

filler must have, above all else, a fine flavor and aroma and a good "burn." In the case of the wrapper leaf there are a number of requirements to be met, among which are sufficient elasticity, proper color, size, and shape, fineness of veins, freedom from objectionable flavor and taste, a fine "grain," and a good burn. Many of these qualities can be determined by simple inspection, without the use of any specific tests, while others require special laboratory methods. The present article has to do only with the practical methods of testing the burn, deferring to a later day a consideration of the chemical characteristics of the tobaccos which have been tested.

There are several elements which go to make a good or bad burn, chief of which are the capacity for holding fire, the evenness of the burn, the color of the ash and its firmness, the coaling or carbonization, and the "puckering" of the leaf immediately in advance of the burning zone of the cigar. The final test of any cigar tobacco must, of course, rest in the smoking of the manufactured cigar, but, while this gives a direct means of determining the character of the ash, it does not furnish accurate information as to the evenness of the burn or the fire-holding capacity of any one of the components of the cigar except with reference to the other two particular components used in the experiment. This is particularly true of the wrapper, as was shown by special experiments carried out to observe the effect of using different fillers and binders with the same wrapper. The result of these experiments will be more fully discussed below. Again, it should be remembered, in this connection, that cigars made by the same workman and from the same lot of tobacco often vary widely in their burn owing to the impossibility of avoiding unevenness in the filler, and this source of error can only be eliminated by several times repeating the experiment. It is evident, therefore, that, in order to get reliable data concerning the relative merits of different wrappers with respect to their burning qualities, the cigar test must be supplemented by some other method capable of giving sharp distinctions as to the fire-holding capacity and evenness of burn.

A method which has long been in use is to ignite the leaf by means of a lighted cigar or a slow-burning match devised by Nessler,[a] and note the number of seconds during which it continues to glow. The mean of several tests is taken as a measure of the capacity for holding fire; but the variation in the results obtained, even upon a single leaf, is so great that little reliance can be placed upon the figures except in a very general way. In this method no account is taken of the area of the leaf burned, and the wide differences obtained on a single leaf are due principally to the fact that frequently the ignited zone soon ceases to glow except for one or more very small streamers, which

[a] Landw. Vers. Stat., XI, 399.

continue to burn for a much longer period, thereby giving results altogether out of proportion to the true burning qualities of the tobacco in question. Another serious objection to the method is found in the interference of the veins of the leaf; for it seldom happens that the glow can cross these veins except around the outer edges of the leaf, while in the cigar the veins always run longitudinally and so do not interfere with the burn.

The rational procedure would seem to be to test the burn of the leaf when wrapped in some such form as is actually found on the cigar, but without the use of binder or filler. We have devised a method of this kind in which the leaf, after being properly wrapped and dried, is burned with the aid of a slow current of air. The current of air compensates in a measure for the absence of the filler and binder, while its use obviates the unavoidable irregularities of the latter. A detailed description of the apparatus used and the method of carrying out the operation will be found on page 11. This test, combined with the smoking of the cigar, has enabled us to accurately classify a large number of samples of wrapper leaf with respect to their burning qualities.

THE SMOKING TEST.

It is evident that no two persons would smoke a cigar in exactly the same way, nor would the same individual smoke two cigars under exactly similar conditions. It is necessary, therefore, to use some means of smoking the cigars artificially in order to eliminate the personal equation and secure uniformity of conditions. Dr. E. H. Jenkins, in the Annual Report of the Connecticut Agricultural Experiment Station for 1892, has described an apparatus for smoking cigars which was devised by Mr. S. L. Penfield, of Yale University. The "pull" on the cigar is secured by means of an aspirator which is filled by a continuous inflow of water and emptied at regular intervals by a siphon. We have modified this apparatus in a number of details in order to adapt it to our needs, and we give herewith a description of the form and dimensions which we have finally adopted for use in our investigations. In this apparatus as many as four cigars may be smoked simultaneously, while held in such a position that they may be readily compared throughout the operation.

By reference to the accompanying illustration (fig. 1) it will be seen that the holders (*a*, *b*, *c*, and *d*) for the cigars are so arranged that they all lie in the same vertical plane, each one 2 inches above and having its horizontal arm 2 inches shorter than the next lower. A screen with a white covering is placed immediately in the rear of the holders to serve as a background, thereby facilitating observation of the character of the ash. Between the flask bearing the holders and the aspirator and connected with these by means of glass tubing is a

check valve consisting of a T-tube (*e*), the lower arm of which dips beneath the surface of the water in a suitable vessel (*f*), thus preventing a backward draft through the cigars while the aspirator is filling. The smoke which escapes through this valve has a very disagreeable odor; hence, it is well to use a bottle fitted with a stopper with two holes, through one of which passes the lower arm of the T-tube (*g*), while through the other passes one end of a long tube (*h*), which carries away the obnoxious fumes. The aspirator consists of a glass cylinder (*i*), the upper end of which is fitted with a rubber stopper

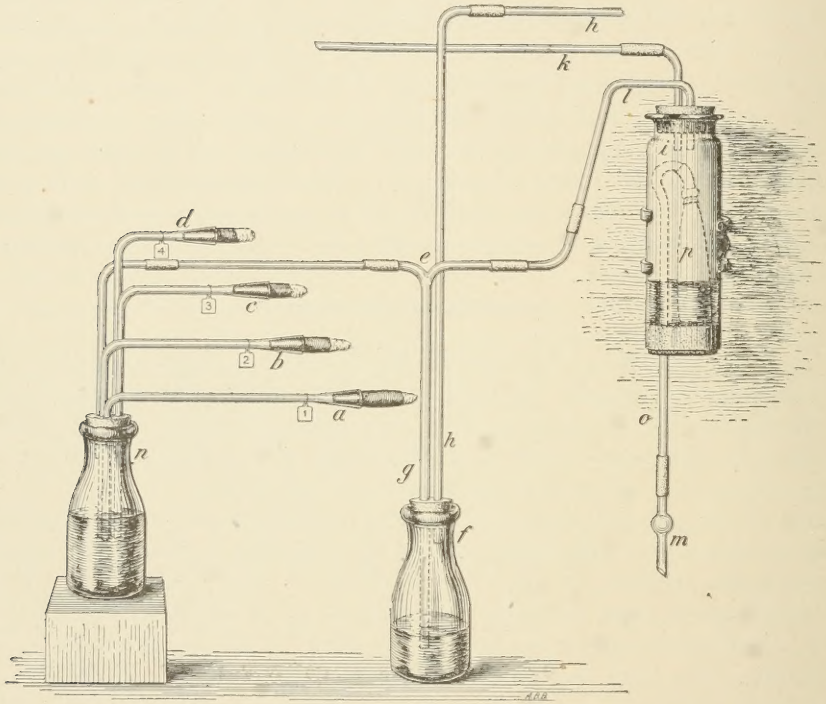

FIG. 1.—Apparatus for testing the burning quality of cigars: *a*, *b*, *c*, *d*, holders for cigars; *e*, T-tube, the lower arm of which, *g*, dips beneath surface of water in *f*; *h*, *h*, tube for leading away tobacco smoke; *i*, aspirator; *k*, tube leading to water supply; *o*, *p*, long and short arms of siphon; *l*, tube connecting cigar holders with aspirator; *m*, tube, with bulb, attached to long arm of siphon; *n*, flask carrying the cigar holders.

containing two holes through which pass tubes leading to the water supply (*k*) and to the flask carrying the cigar holders (*l*), respectively. The lower end of the cylinder is closed with a rubber stopper bearing the small arm of the siphon (*o*). The tube furnishing the water supply is connected with a reservoir provided with a constant-level attachment. To the lower end of the small arm of the siphon is attached a glass tube (*m*) bearing a small bulb which materially assists in breaking the flow of the water at the moment the aspirator is emptied. The tubing connecting the parts of the apparatus should not be less than

6 to 8 mm. internal diameter; otherwise the tubes will frequently become clogged by the condensation products of the smoke. The container for the cigar holders (*n*) is filled about two-thirds full with dilute sulphuric acid, which serves as an acid wash for the smoke, retaining the organic bases and thereby further helping to prevent the choking up of the machine. The lower ends of all the cigar holders should, of course, extend to exactly the same depth below the surface of the acid.

In the machine which we now have in operation, the relation between the short arm of the siphon and the internal diameter of the aspirator is such that the volume of water delivered at each emptying of the latter is 600 c.c. This corresponds to an actual capacity of about 450 c.c. for the aspirator, the difference, of course, representing the volume of water entering the aspirator from the supply pipe while the siphon is in action. The rate of inflow from the supply tank is approximately 900 c. c. per minute. The internal diameter of the long arm of the siphon is 8 mm., while that of the short arm is 25 mm. The entire length of the long arm of the siphon exceeds that of the short arm by 40 cm. An apparatus of the above-mentioned dimensions will smoke four cigars of the Perfecto type, 4¾ inches in length, in about thirty minutes, a rate which is probably somewhat above that of the average smoker. The pull on the cigar occurs at intervals of thirty seconds and continues for a period of ten seconds. The frequency of the pull is controlled by the rate of inflow of the water from the supply tank, while its duration is governed principally by the relation between the diameter of the small arm of the siphon and the volume of the aspirator.

THE EFFECTS OF THE FILLER, THE BINDER, AND THE WRAPPER ON THE BURN OF THE CIGAR.

As preliminary to the use of the cigar test in examining wrapper leaf, a series of experiments was carried out to determine the relative effects of the three components of the cigar on the burn. For this purpose a number of cigars were made by an expert workman, using four different types of wrapper on each of four different types of filler. In a portion of the cigars the binder used was taken from the same leaf as the wrapper, while in the remainder a sample of Connecticut Broadleaf tobacco was employed for this purpose. These cigars were smoked in the above-described apparatus under conditions as nearly uniform as could be obtained, and the evenness of the burn and the character of the ash were carefully noted.

With reference to the evenness of the burn, markedly different results were obtained when wrappers taken from the same sample were smoked on different types of filler. A typical case of this kind is shown in Plate I. The twelve cigars shown were all made from the same

sample of wrapper, and in each case the binder was taken from the same leaf as the wrapper. In the first group (A), a sample of filler grown in Texas from Cuban seed was used; in the second group (B), a heavy filler grown in Ohio from domestic seed; in the third group (C), a filler grown in South Carolina from Cuban seed; in the fourth group (D), an imported Cuban filler. The wrapper used on these cigars was a type of Sumatra tobacco grown in Connecticut and had a very good burn. The Texas and imported Cuban fillers were known to have an excellent burn, while the South Carolina filler was markedly inferior in this respect and the Ohio filler intermediate in burning qualities. It will be seen that this sample of wrapper burned quite evenly when used with the imported Cuban and Texas fillers, while with the Ohio and especially the South Carolina fillers the burn was decidedly uneven.

On the other hand, the effect of using different types of wrapper on the evenness of burn of any one type of filler was less marked (see Pl. II, A, B, and C; also Pl. I, D). The filler used in this experiment was the imported Cuban, while the wrappers were taken from four different types of Sumatra tobacco grown in Connecticut. Of these four types of wrappers, that shown in Plate I, group D, had the best burn and the one shown in Plate II, group C, the poorest, although little difference could be seen between the two when smoked on the Cuban filler. The use of different binders did not cause any marked differences in the evenness of the burn, as is shown in Plate II, groups C and D. The cigars used in this experiment were all made from the same wrapper and the same filler, while in group D a sample of Connecticut Broadleaf tobacco was used as the binder, and in group C the binder was taken from the same leaf as the wrapper.

Another important factor in determining the evenness of the burn is the proper balancing of the component parts of the cigar. It was found, for example, that a very light[a] wrapper will not give good results on a heavy filler, even though both of these may in themselves possess a good burn. It will readily be seen that a very thin wrapper which burns readily and very rapidly will, when placed on a heavy, slow-burning filler, tend to burn in advance of the latter, and the effect will generally be an uneven burn. The same result is obtained when any cigar is smoked very rapidly, for the reason that the oxygen of the air has freer access to the outer edges of the burning zone and under the added stimulus it rarely happens that a cigar will burn evenly.

As regards the character of the ash, the wrapper and the binder are relatively of much more significance. It was found, it is true, that some fillers give an ash lacking in compactness and liable to split asunder, but the tendency to flake seems to be controlled almost entirely

[a] The terms *light* and *heavy* as used in this connection refer to the body or thickness of the leaf, which largely controls the rapidity of the burn.

by the character of the wrapper and binder. Furthermore, this lack of cohesion in the ash of a wrapper may be largely overcome by the use of a good binder. As to the color of the ash, a binder having a good burn will impart to the ash of the wrapper a lighter tint and a more uniform color. The general results of these experiments may be summarized as follows:

(1) In order to secure a good burn, due consideration should be given to the proper balancing of the components of the cigar; that is, a heavy filler should be wrapped with a comparatively heavy wrapper, while a light-bodied filler requires a light-bodied wrapper.

(2) Of the three components of the cigar, the filler exerts the strongest influence on the evenness of the burn.

(3) The influence of the wrapper and binder is shown most strongly on the character of the ash, and the binder very materially influences the ash of the wrapper in this respect.

TESTING THE CAPACITY FOR HOLDING FIRE AND THE EVENNESS OF THE BURN.

The factors of holding fire and of burning evenly are of prime importance in judging the burn of tobacco, and any sample found markedly deficient in these points may be rejected without applying any further test. As has been previously stated, the old method of measuring the fire-holding capacity is likely to lead to erroneous conclusions, while there has heretofore been no direct method of determining the evenness of the burn of wrapper leaf. In the process which we have used for testing wrapper tobacco with regard to these elements of the burn, the area of the leaf consumed, rather than the time elapsing before the glow is extinguished, is measured.

The form of the apparatus used in this method will be understood by reference to the accompanying illustration (fig. 2). The essential feature is the form on which the leaf is wrapped, consisting of a collapsible wooden tube, one end of which fits into a glass tube of the same diameter. This latter is in turn connected with a second glass tube through which is drawn a current of air. The best material for making the wooden form is well-seasoned cherry with a straight grain, but ash has also been found to answer the purpose very well. From the wood selected is made a cylinder 5 inches in length, $\frac{3}{4}$ inch in diameter at one end, and tapering slightly to the other end (see fig. 3). In the larger end of the cylinder a $\frac{3}{4}$-inch hole is bored to a depth of $3\frac{7}{8}$ inches, and the shell thus formed is separated into six equal segments by sawing to a depth of $3\frac{1}{2}$ inches. The smaller end is cut down for a distance of $1\frac{1}{2}$ inches, so as to fit snugly into the glass tube. The shoulder thus formed should correspond in depth to the thickness of the wall of the glass tube. Near the larger end of the form a groove (*c*) is cut, into which is fitted a rubber band. The plug (*d*) has a diameter such

that when inserted in the end of the form the latter is expanded to its original size. The receiver (*a*) for the form is made by drawing out

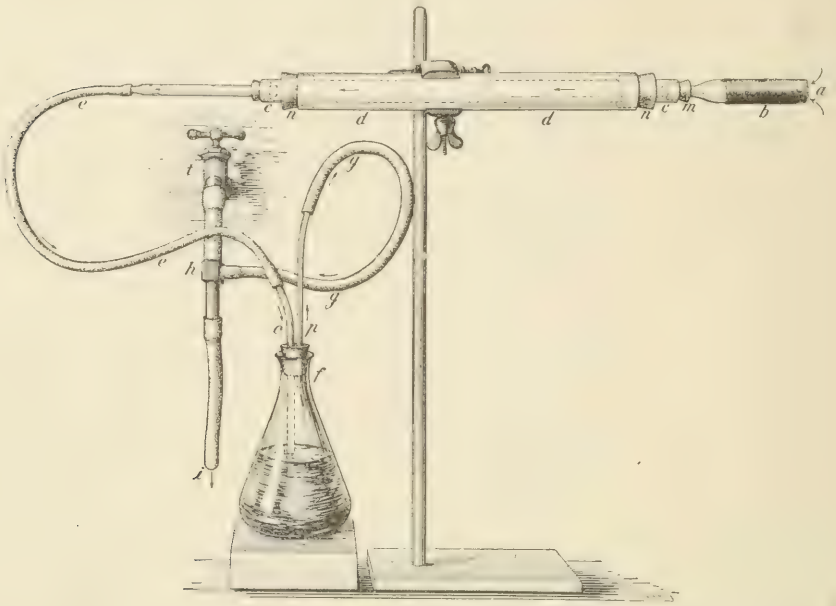

FIG. 2.—Apparatus for testing the burning quality of wrapper tobacco: *a*, entrance of air current; *b*, wrapper to be tested; *c*, *c*, glass tube to which the form bearing the wrapper is attached by means of the cork, *m*; *d*, *d*, large glass tube fitted with corks, *n*, *n*, through which passes *c*, *c*; *f*, flask containing water; *o*, small glass tube dipping beneath the surface of the water in *f*; *p*, short glass tube leading from *f*; *h*, pump by means of which the current of air is secured; *e*, *e* and *g*, *g*, rubber tubing connecting parts of apparatus; *t*, water tap; *i*, outflow of water.

one end of a short piece of thick-walled glass tubing. All of the above dimensions are based on tubing having an internal diameter of 14 mm. (9 16 inch) and an external diameter of 18 mm. (11 16 inch). The small end of the receiver is fitted with a soft cork (*b*), by means of which it is connected with the other portion of the apparatus.

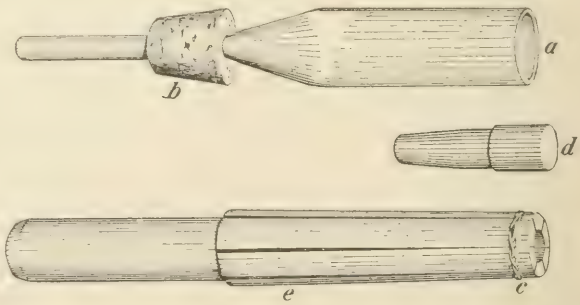

FIG. 3.—Construction of form on which leaf is wrapped for use in apparatus shown in figure 2: *a*, glass tube for receiving the form; *b*, cork by which receiver *a* is connected with remainder of apparatus shown in figure 2; *c*, rubber band for collapsing the form; *d*, plug for expanding the form; *e*, form on which leaf is wrapped.

From the leaf to be tested, which should be quite damp, the wrapper is cut into a form quite similar to that used for cigars, and the same rules are observed as regards the cutting of right-handed and left handed wrappers, etc. Beginning at the outer end the wrapper is

rolled quite tightly, first on the form and then on the glass. At the beginning of the process of rolling, the extreme outer corner of the base of the wrapper is attached to the overlapping portion with a bit of cigar paste, and at the end of the operation the tip of the wrapper is attached to the receiver by the same means. A number of samples to be tested are thus wrapped on the forms and set aside until they have dried out properly. The plug in the end of the form is then withdrawn and the rubber band causes the walls of the latter to collapse, so that it can be easily withdrawn from the receiver. This leaves the sample of wrapper securely attached to the glass tube, and in exactly the same form it would have on a cigar. The tube carrying the sample to be tested is connected with the remainder of the apparatus, shown in figure 2, the construction of which will be understood without further explanation. The current of air is furnished by means of an ordinary filter pump, and its rate can be controlled with sufficient accuracy by measuring the flow of water through the pump. The end of the wrapper is ignited with a flat gas flame, and the evenness of the burn and the portion consumed before it ceases to glow are carefully noted. Our method of recording the results is to grade each sample on a scale of ten, both with reference to the evenness of the burn and the fire-holding capacity. Of course, standards in these tests are purely arbitrary, as the results are only intended to be comparative. Under the conditions laid down for the experiment, wrappers having markedly good burning qualities will burn up completely and evenly with only one lighting, and these are given a grade of 10.

For the purpose of comparing the results obtained by this method with those given by the cigar test with reference to the evenness of the burn, a number of leaves were selected from different types of wrapper tobacco. One half of each leaf was used for wrapping a cigar and the second half was wrapped on the form for testing, as has just been described. There was a decided lack of agreement in the results obtained by the two methods when only one type of filler was used in making the cigars. It was found that frequently a wrapper that graded only 5 or 6 on a scale of 10 in what may be called the "form test" would burn quite evenly on the cigar, whereas another wrapper grading as high as 9 in this test would show an uneven burn on the cigar. A good illustration of this point is found in a wrapper which was scored 10, 9, 10, respectively, in three experiments with the form test and gave a fire-holding capacity of 65 seconds by the old method of Nessler. On one type of filler this wrapper gave a very uneven burn, but when smoked on a lighter filler the burn was perfectly satisfactory. These results, then, seem to emphasize the fact that, although the final judgment as to the burning qualities of a wrapper which has shown up well in the preliminary tests must be based on the smoking

of the cigar, great care must be exercised to avoid the sources of error in this test which have been previously discussed. The test should not only be repeated with a single type of filler to avoid the effects of any possible unevenness or other imperfections in the manufacture of the cigars, but at least two different types of filler should be used, one of these being heavy and the other light in the sense in which these terms are used here.

TESTING THE BURN OF CIGAR-FILLER TOBACCO.

Testing the burn of a filler is a much simpler problem than is the case with a wrapper. The principal elements of the burn are the evenness and the capacity for holding fire, and the character of the ash is unimportant, except that it should be compact. The evenness of the burn and the fire-holding capacity are best determined by using the cigar test. In the case of filler tobacco the capacity for holding fire thus refers simply to the length of time the cigar will continue to burn after being lighted without being puffed by the smoker. The effects of the binder and wrapper on the burn may be avoided by making the entire cigar from the filler leaf to be tested. Another decided advantage in making the whole cigar from the same tobacco is that the aroma, which is so important in the filler, can also be tested at the same time. In determining the fire-holding capacity it is only necessary to light the cigar and test it at gradually increasing intervals of time to find whether it has ceased to burn. It is, however, desirable to test the fire-holding capacity and the evenness of the burn on separate cigars if sufficient material is at hand for this purpose.

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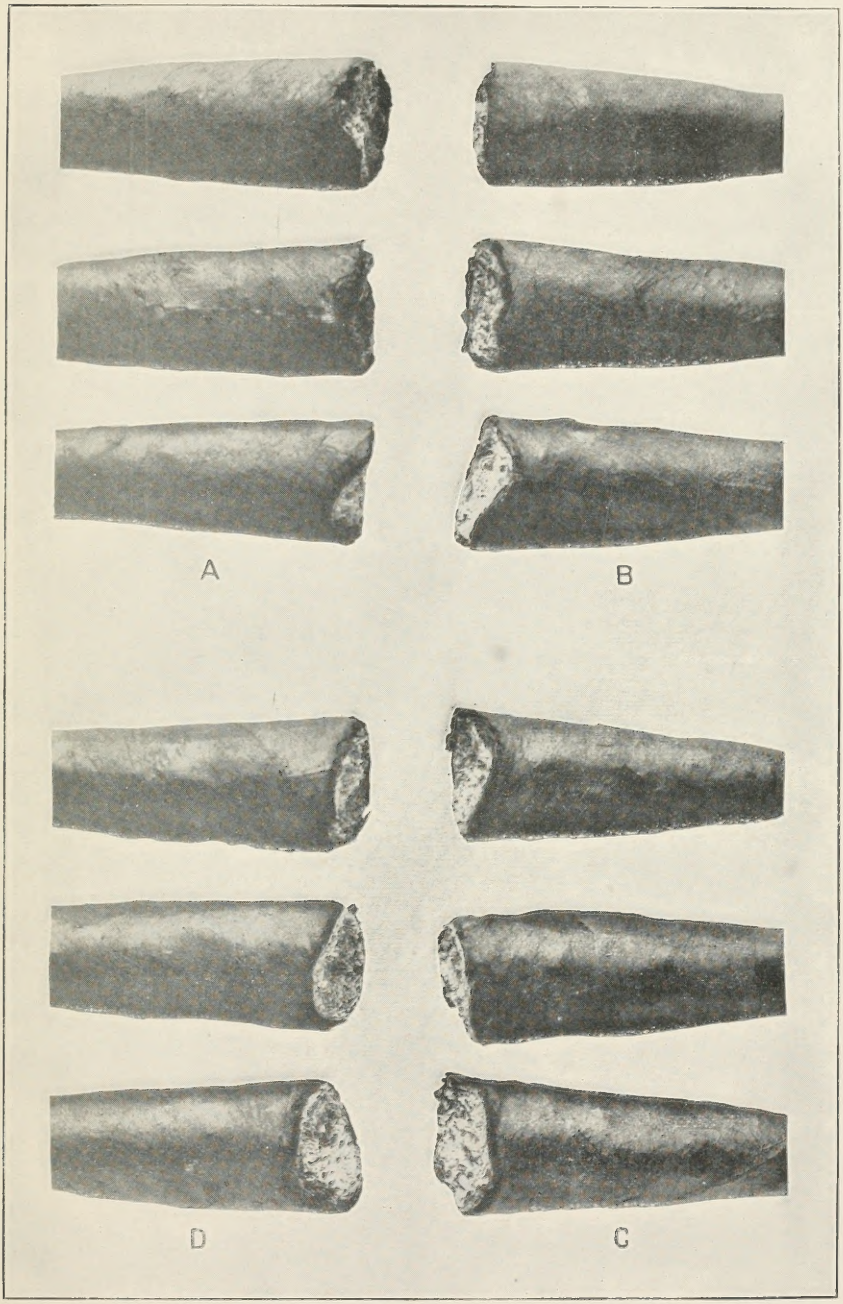
VARIATION IN BURN OF WRAPPERS DUE TO DIFFERENT FILLERS: A, FILLER GROWN IN TEXAS FROM CUBAN SEED; B, FILLER GROWN IN OHIO FROM DOMESTIC SEED; C, FILLER GROWN IN SOUTH CAROLINA FROM CUBAN SEED; D, AN IMPORTED CUBAN FILLER.

The same sample of Sumatra wrapper was used throughout and the binder was taken from the same leaf as the wrapper in each case.



VARIATION IN BURN OF FILLERS DUE TO DIFFERENT WRAPPERS AND BINDERS: A, B, C, THREE DIFFERENT TYPES OF CONNECTICUT-GROWN SUMATRA WRAPPER ON SAME SAMPLE OF CUBAN FILLER, BINDER BEING SAME AS WRAPPER IN EACH CASE; D, SAME WRAPPER AND FILLER AS C, BUT CONNECTICUT BROADLEAF USED AS BINDER.

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